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(54) Cutting elements and methods of manufacture thereof

(57) A cutting element for a rotary drill bit includes at least one insert (20) of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst. The insert (20) is mounted by being at least partly surrounded by a support body (21) of conventional polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from cobalt and other iron group elements or alloys thereof. The insert (20) and support body (21) may be integrally bonded to a substrate during manufacture. Either the insert (20) or support body (21) may be pre-sintered or sintered during formation of the cutting element.

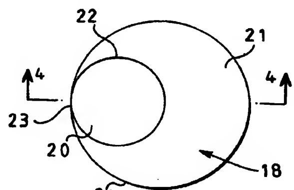

FIG 3

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Description

[0001] The invention relates to cutting elements and in particular to cutting elements for rotary drill bits, such as drag-type drill bits and rolling cutter drill bits. However, the invention may also be applicable to the manufacture of cutting elements for use in machine tools and the like.

[0002] As is well known, one common form of cutting element for a rotary drag-type drill bit is a two-layer or multi-layer cuffing element where a facing table of polycrystalline diamond is integrally bonded to a substrate of less hard material, such as tungsten carbide. The cutting element is usually in the form of a tablet, usually circular or part-circular. The substrate of the cuffing element may be brazed to a carrier, usually also of cemented tungsten carbide, which is received in a socket in the bit body, or the substrate itself may be of sufficient axial length to be mounted directly in a socket in the bit body.

[0003] As is well know, polycrystalline diamond is formed by sintering diamond powder with a suitable binder-catalyst in a high pressure, high temperature press. Hitherto, the polycrystalline diamond employed in cuffing elements for rotary drill bits has been of three basic types.

[0004] In the most common type, which will hereinafter be referred to as "conventional" polycrystalline diamond, the binder-catalyst is cobalt. In one common process for manufacturing two-layer cutting elements, diamond powder is applied to the surface of a preformed tungsten carbide substrate incorporating cobalt. The assembly is then subjected to very high temperature and pressure in a press. During this process cobalt migrates from the substrate into the diamond layer and acts as a binder-catalyst, causing the diamond particles to bond to one another with diamond-to-diamond bonding, and also causing the diamond layer to bond to the substrate.

[0005] Although cobalt is most commonly used as the binder-catalyst, any iron group element, such as cobalt, nickel or iron, or alloys thereof, may be employed.

[0006] The disadvantage with such conventional polycrystalline diamond is that the material is not thermally stable beyond about 750 C, due to the presence of the metallic binder, which causes the diamond to graphitise. Also, the difference in coefficient of thermal expansion of the diamond and cobalt may also cause deterioration of the diamond layer with increase in temperature above about 500 C.

[0007] In order to overcome these problems so-called "thermally stable" polycrystalline diamond components have been produced and are sometimes used in drag-type drill bits. In one type of thermally stable diamond the cobalt or other binder-catalyst in conventional polycrystalline diamond is leached out of the diamond after formation. While this may increase the heat-resistance of the diamond to about 1200°C, the leaching process also removes the cemented carbide substrate which leads to severe difficulties in mounting such material on a drill bit.

[0008] In an alternative form of thermally stable diamond, silicon carbide is used as the binder-catalyst Again, the thermal resistance of the diamond is improved, but again difficulties are encountered in mounting the material for use on a drag-type drill bit.

[0009] More recently, a further type of polycrystalline diamond has become available in which carbonates, such as powdery carbonates of Mg, Ca, Sr, and Ba, or two or more types of these carbonates, are used as the binder-catalyst when sintering the diamond powder. Polycrystalline diamond materials of this kind are described, for example, in Japanese Patent Laid-Open Publications Nos. 74766/1992 and 114966/1992, the contents of which are incorporated herein by reference.

[0010] Polycrystalline diamond of this type has significantly greater wear-resistance and hardness than the types of polycrystalline diamond hitherto used as cuffing elements in drill bits. The material is difficult to produce on a commercial scale since much higher temperatures and pressures are required for sintering than is the case with conventional and thermally stable polycrystalline diamond. One result of this is that the bodies of polycrystalline diamond produced by this method are smaller than conventional polycrystalline diamond elements. This, together with other characteristics of the material makes it difficult to mount bodies of the material in such a way that they may be used as cuffing elements in rotary drill bits.

[0011] The present invention sets out to overcome these problems and to provide novel arrangements and methods for mounting polycrystalline diamond of this kind in a manner where the material may be used in cuffing elements for rotary drill bits.

[0012] According to the invention there is provided a cuffing element including at least one insert of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, said insert being at least partly surrounded by a support body of polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof.

[0013] The insert and support body may each be in the form of a tablet having a front surface, a rear surface and a peripheral surface. Preferably the front surface of each of the insert and support body is substantially parallel to the rear surface thereof. Preferably also a part of the peripheral surface of the insert forms a continuation of the peripheral surface of the support body.

[0014] The thickness of the insert, between the front and rear surfaces thereof, may be substantially the same as the thickness of the support body, so that the front surface of the insert is substantially co-planar with the front surface of the support body and the rear surface of the insert is substantially co-planar with the rear surface of the support body.

[0015] In an alternative embodiment said insert is totally embedded in the support body, so that no part of the insert is exposed. In this case the front surface of the insert may be inclined to the front surface of the support body.

[0016] In another embodiment there are provided a plurality of inserts embedded in a larger support body.

[0017] In any of the above arrangements according to the invention the rear surface of the support body may be bonded to a surface of a substrate of a material which is less hard than the support body.

[0018] The invention also provides a cutting element comprising at least one body of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst the body having a front surface, a rear surface and a peripheral surface, and the rear surface of the body being bonded to a surface of a substrate of a material which is less hard than the material of the body.

[0019] The invention further provides a method of forming a cutting element including at least one insert of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, said insert being at least partly surrounded by a support body of polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof, the method comprising the steps of:

pre-sintering said insert in a high pressure, high temperature press,
at least partly surrounding the pre-sintered insert with a mixture including diamond powder and binder-catalyst selected from iron group elements or alloys thereof, and
subjecting the pre-sintered insert and the powder mixture to high pressure and high temperature in a press to sinter the mixture and bond it to the preformed insert.

[0020] An alternative method comprises the steps of:

pre-sintering the insert in a high pressure, high temperature press,
separately pre-sintering the support body in a high pressure, high temperature press,
combining the pre-sintered insert and support body together in an assembly where the support body at least partly surrounds the insert, and
subjecting the assembly to high pressure and temperature in a press to bond the insert to the support body.

[0021] A further alternative method comprises the steps of:

forming a first mixture including diamond powder and a powdered carbonate binder-catalyst,
forming a second mixture including diamond powder and a powdered binder-catalyst selected from iron group elements or alloys thereof,
disposing bodies of said mixtures so that the second mixture at least partly surrounds the first mixture, and
subjecting the mixtures to high pressure and high temperature in a press to sinter the first and second mixtures and bond them to one another.

[0022] A still further alternative method comprises the steps of:

pre-sintering the support body in a high pressure, high temperature press,
forming a mixture including diamond powder and a powdered carbonate binder-catalyst,
combining the mixture with the pre-sintered support body to form an assembly in which the support body at least partly surrounds the mixture, and
subjecting the assembly to high pressure and temperature in a press to sinter the insert and to bond the insert to the pre-sintered support body.

[0023] Each of the above methods may include the further step of applying the insert and support body, either pre-sintered or as a mixture including diamond powder and binder-catalyst, to a preformed substrate prior to subjecting the whole assembly to high pressure and temperature in a press, so that the insert and support body are bonded to the substrate.

[0024] In methods where the support body is sintered while in contact with the substrate, as opposed to being pre-sintered, the necessary iron group binder-catalyst may be derived from the substrate instead of, or in addition to, being mixed with the diamond powder applied to the substrate.

[0025] Accordingly, the invention also provides a method comprising the steps of:

pre-sintering said insert in a high pressure, high temperature press,
preforming a substrate incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof,
forming an assembly by applying to a surface of the substrate said pre-sintered insert and a body including diamond powder in such manner that the diamond powder at least partly surrounds the insert, and
subjecting the assembly to high pressure and high temperature in a press, to cause some of said sintering binder-catalyst incorporated in the substrate to migrate from the substrate into the body of diamond powder, whereby the diamond powder is sintered and bonded to both the substrate and to the insert, and the insert is also bonded to the substrate.

16. A cutting element according to Claim 14 wherein the rear surface of the insert (20) is co-planar with the rear surface of the support body (21) and is also bonded to said surface of the substrate (19).

17. A cutting element comprising at least one body (20) of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, the body (20) having a front surface, a rear surface and a peripheral surface, and the rear surface of the body (20) being bonded to a surface of a substrate (19) of a material which is less hard than the material of the body (20).

18. A method of forming a cutting element including at least one insert (20,25,31,34,40) of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, said insert (20,25,31,34,40) being at least partly surrounded by a support body (21,26,33,35,41) of polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof, the method comprising the steps of:

pre-sintering said insert (20,25,31,34,40) in a high pressure, high temperature press,
at least partly surrounding the pre-sintered insert (20,25,31,34,40) with a mixture including diamond powder and binder-catalyst selected from iron group elements or alloys thereof, and
subjecting the pre-sintered insert (20,25,31,34,40) and the powder mixture to high pressure and high temperature in a press to sinter the mixture and bond it to the preformed insert.

19. A method according to Claim 18 incorporating the further step of applying the insert (20,25,31,34,40) and mixture including diamond powder and binder-catalyst to a preformed substrate (19,27) prior to subjecting the insert (20,25,31,34,40), mixture and substrate (19,27) to high pressure and temperature in a press, so that the insert (20,25,31,34,40) and support body (21,26,33,35,41) are bonded to the substrate (19,27).

20. A method of forming a cutting element including at least one insert (20,25,31,34,40) of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, said insert (20,25,31,34,40) being at least partly surrounded by a support body (21,26,33,35,41) of polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof, the method comprising the steps of:

pre-sintering said insert (20,25,31,34,40) in a high pressure, high temperature press,
preforming a substrate (19,27) incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof,
forming an assembly by applying to a surface of the substrate (19,27) said pre-sintered insert (20,25,31,34,40) and a body (21,26,33,35,41) including diamond powder in such manner that the diamond powder at least partly surrounds the insert (20,25,31,34,40), and
subjecting the assembly to high pressure and high temperature in a press, to cause some of said sintering binder-catalyst incorporated in the substrate (19,27) to migrate from the substrate (19,27) into the body of diamond powder, whereby the diamond powder is sintered and bonded to both the substrate (19,27) and to the insert (20,25,31,34,40), and the insert is also bonded to the substrate (19,27).

21. A method of forming a cutting element including at least one insert (20,25,31,34,40) of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, said insert (20,25,31,34,40) being at least partly surrounded by a support body (21,26,33,35,41) of polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof, the method comprising the steps of:

pre-sintering the insert (20,25,31,34,40) in a high pressure, high temperature press,
separately pre-sintering the support body (21,26,33,35,41) in a high pressure, high temperature press,
combining the pre-sintered insert (20,25,31,34,40) and support body (21,26,33,35,41) together in an assembly where the support body at least partly surrounds the insert, and
subjecting the assembly to high pressure and temperature in a press to bond the insert to the support body.

22. A method according to Claim 21 incorporating the further step of applying the pre-sintered insert and support body to a preformed substrate (19,27) prior to subjecting the insert, support body and substrate to high pressure and temperature in a press, so that the insert and support body are bonded to the substrate.

23. A method of forming a cutting element including at least one insert (40) of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, said insert (40) being at least partly

surrounded by a support body (41) of polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof, the method comprising the steps of:

forming a first mixture including diamond powder and a powdered carbonate binder-catalyst, forming a second mixture including diamond powder and a powdered binder-catalyst selected from iron group elements or alloys thereof,
disposing bodies of said mixtures so that the second mixture at least partly surrounds the first mixture, and
subjecting the mixtures to high pressure and high temperature in a press to sinter the first and second mixtures and bond them to one another.

24. A method according to Claim 23 incorporating the further step of applying the mixtures of diamond powder and binder-catalyst to a preformed substrate prior to subjecting the mixtures and substrate to high pressure and temperature in a press, so that the insert and support body formed from the mixtures are bonded to the substrate.

25. A method of forming a cutting element including at least one insert (20,25,31,34,40) of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, said insert being at least partly surrounded by a support body (21,26,33,35,41) of polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof, the method comprising the steps of:

forming a mixture including diamond powder and a powdered carbonate binder-catalyst,
preforming a substrate incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof,
forming an assembly by applying to a surface of the substrate a body of said mixture and a body including diamond powder in such manner that the body including diamond powder at least partly surrounds the body of said mixture, and
subjecting the assembly to high pressure and high temperature in a press to sinter the mixture and bond it to the substrate, and to cause some of said sintering binder-catalyst incorporated in the substrate to migrate from the substrate into the body of diamond powder, whereby the diamond powder is sintered and bonded to both the substrate and to the sintered mixture.

26. A method of forming a cutting element including at least one insert (20,25,31,34,40) of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, said insert being at least partly surrounded by a support body (21,26,33,35,41) of polycrystalline diamond of a kind incorporating a sintering binder-catalyst selected from iron group elements or alloys thereof, the method comprising the steps of:

pre-sintering the support body in a high-pressure, high temperature press,
forming a mixture including diamond powder and a powdered carbonate binder-catalyst,
combining the mixture with the pre-sintered support body to form an assembly in which the support body at least partly surrounds the mixture, and
subjecting the assembly to high pressure and temperature in a press to sinter the insert and to bond the insert to the pre-sintered support body.

27. A method according to Claim 26 incorporating the further step of applying the assembly to a preformed substrate (19,27) prior to subjecting the assembly and substrate to high pressure and temperature in a press, so that the insert and support body are bonded to the substrate.

28. A method of forming a cutting element comprising at least one body of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, the body having a front surface, a rear surface and a peripheral surface, and the rear surface of the body being bonded to a surface of a substrate (19,27) of a material which is less hard than the material of the body, the method including the steps of:

pre-sintering the insert and preforming the substrate,
locating a surface of the insert in contact with a surface of the substrate, and
subjecting the insert and substrate to high pressure and temperature in a press to bond the insert to the substrate.

29. A method of forming a cutting element comprising at least one body of polycrystalline diamond of a kind incorporating a carbonate as a sintering binder-catalyst, the body having a front surface, a rear surface and a peripheral surface, and the rear surface of the body being bonded to a surface of a substrate of a material which is less hard than the material of the body, the method including the steps of:

preforming a substrate,

placing in contact with the substrate a mixture including diamond powder and a powdered carbonate binder-catalyst, and

subjecting the mixture and substrate to high pressure and temperature in a press to sinter the mixture to form the insert, and to bond the insert to the substrate.

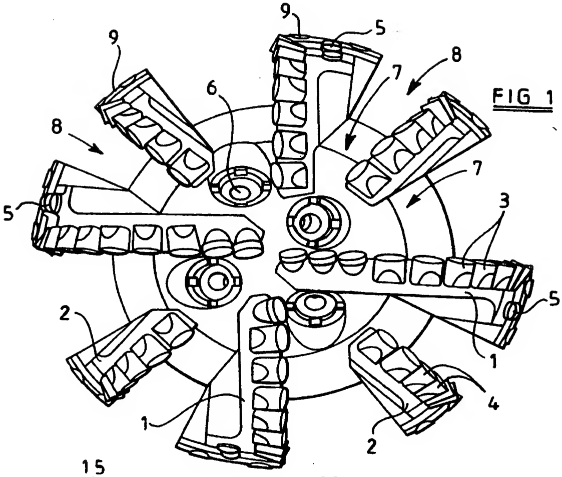

FIG 1

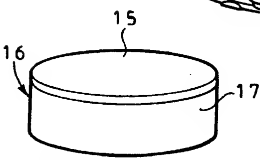

FIG 2

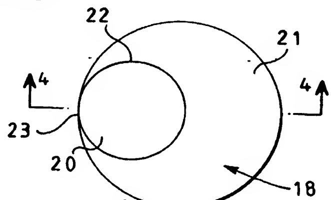

FIG 3

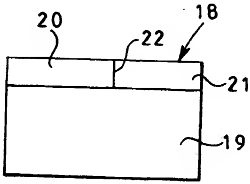

FIG 4

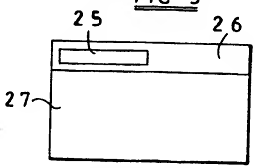

FIG 5

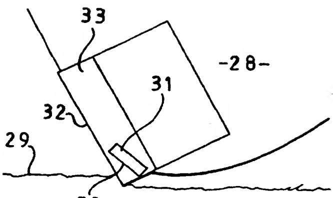

FIG 6

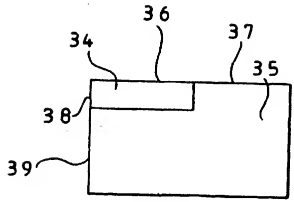

FIG 7

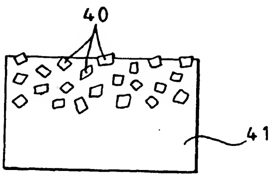

FIG 8

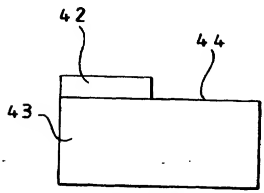

FIG 9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 30 5411

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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

C04B
E21B
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	7 November 2000	Hauck, H

CATEGORY OF CITED DOCUMENTS

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